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RESEARCH IN THE COASTAL AND OCEANIC ENVIRONMENT.(U)
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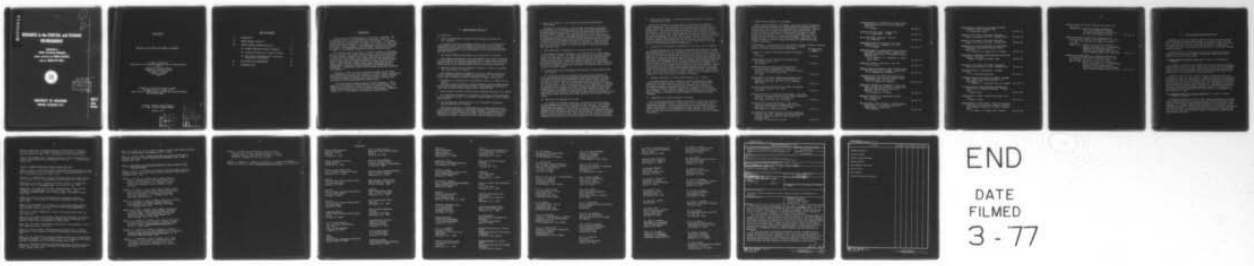

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RESEARCH in the COASTAL and OCEANIC ENVIRONMENT

submitted to
OFFICE OF NAVAL RESEARCH
under contracts no. N00014-69-A0407
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UNIVERSITY OF DELAWARE
NEWARK, DELAWARE 19711

1977
FINAL
REPORT

Final Report

RESEARCH IN THE COASTAL AND OCEANIC ENVIRONMENT

A Summary of Research
Undertaken for the Geography Programs, Office of Naval Research
by the
Colleges of Arts and Science,
Engineering, and Marine Studies
University of Delaware
Newark, Delaware
19711

Submitted to cover work during the period
1 September 1969 to 31 August 1975
Under Office of Naval Research Contract Nos. N000-14-69-A0407
and N000-14-75-0876

William S. Gaither, Program Manager
C. Y. Yang, Associate Program Manager

January, 1977

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I. INTRODUCTION

This report covers accomplishments for the period 1 September, 1969 to 31 August, 1975 of an interdisciplinary investigation under the program, "Research in the Coastal and Oceanic Environment." The program was undertaken at the University of Delaware under Contract No. N000-14-69-A0407 and No. N000-14-75-0876. It had undergone a significant redirection as a result of the termination of the *DOD Themis Program* and the transfer of support to the Geography Programs of the Office of Naval Research.

Past activities at the University of Delaware represent a coordinated effort in research that covers a wide spectrum of topics including studies of energy exchange, sedimentary processes, vegetative growth, properties of marine soils and sediments, wave energy concentration, dissipation of waves in shore areas, wave breaking characteristics, wave defense devices, method of predicting wave height and direction, tides, winds and storm surges, dynamic geological models, remote sensing techniques for wave reconnaissance, mechanics of sediment movement, and biogeochemistry of marsh gases. A substantial amount of basic information has been researched and documented.

Beginning in 1972, the research program at Delaware was reoriented toward developing predictive tools tailored to the Navy's needs. Specifically, this new effort was concentrated in three major areas -- dynamic modeling of coastal conditions, stochastic prediction of coastal processes, and photo-optical and field determination of wave spectra.

For the DOD Themes Program covering the period September 1, 1969 to August 31, 1972, William S. Gaither served as the Program Manager. Since 1972 and up to December 31, William S. Gaither served as the Program Manager with Vytautas Klemas as the Associate Program Manager. Beginning in May, 1975 C. Y. Yang served as the Associate Program Manager.

II. THEMIS PROGRAM (1969-1972)

(a) Subprojects

1. Study of Energy Budget in Delaware Ocean Frontage and Delaware Bay (F.E. Camfield)

In a natural coastal area, dynamic processes that occur are governed in large measure by the input and dissipation of energy in various forms. Attention has been centered on nearshore sediment processes using physical and mathematical models to develop knowledge of their interrelationship with waves and currents.

2. The Coastal Sedimentary Environment (J.C. Kraft and R.E. Sheridan)

This program was formulated to provide geomorphic and geologic information about the coastal and nearshore marine areas and to clarify factors affecting coastal change so that processes responsible for the advance and recession of shorelines and for the existing geologic setting can be better understood.

3. Sampling, Classification and Mechanical Properties of Soils and Sediments (W.L. Preslan and R.L. Nicholls)

This subproject serves the program as a whole for laboratory analysis of soils by uniform methods with emphasis on measurements of such properties as grain-size distribution, density, compressive strength and plasticity.

4. Development and Consolidation of Sand Reefs (H. Wells, F.C. Daiber and L.A. Curtis)

Sand reef structures erected in coastal intertidal areas may afford natural protection for beaches against waves erosion. This program was undertaken to locate existing reefs along the western shore of Delaware Bay.

5. Rooted Aquatics and Their Interaction with Sublittoral Processes (J.E. Taylor)

This program was formulated to investigate rooted aquatic plant-sedimentary process interactions as part of the overall characterization of coastal sedimentary processes.

6. Soil and Vegetation Characteristics of a Low Lying Marsh Fringe-Sand Barrier Coast Line (L.J. Cotnoir)

Tidal marsh lands make up a substantial part of coastal shorelines such as those under investigation in this overall program. Knowledge of the underlying soils from the standpoint of porosity and engineering properties are important for a variety of the Navy's needs. This program was initiated to investigate the nature of marsh plants reflecting soil conditions beneath.

7. Ground Water Behavior in the Littoral and Backshore Marsh Regions. (R.D. Varrin)

The behavior of ground water in the littoral and backshore marsh areas of the seacoast has an important bearing on many other natural phenomena including configuration and position of the salt water-fresh water interface, the availability of potable water, vegetation growth and the character of subsoils. In this program, a thorough understanding of ground water behavior at the Delaware seacoast is being sought through the use of a vertical viscous-flow (Hele-Shaw) analog model in which carefully formulated glycerol solutions of different densities simulate salt water and freshwater. These solutions are fed to the opposite ends of the model to establish the salt water-fresh water interface which assumes a curved profile with the salt water extending under the fresh water.

8. Microclimatological Investigation in a Coastal Area (R.T. Field)

The objective of this investigation is to characterize the climatological fluxes of radiant, thermal, and kinetic energy between land and water surfaces and the lower atmosphere in the coastal environment and to establish models capable of predicting such fluxes from simple meteorological observations. By relating energy flows to shoreline phenomena including wave development, beach and dune formation, and the biological processes in the coastal ecosystem, it should be possible to predict more accurately the probable future course of events in the coastal region.

9. A Study of Some Factors Influencing the Generation of Water Waves by Wind (B.S. Seidel)

It is generally accepted that surface waves on water are generated by wind. This phenomenon has been extensively studied beginning with the work of Helmholtz and Kelvin whose mathematical model studies yielded a predicted value for the critical wind velocity required to generate surface waves of 21.3 feet per second. This is a variance with other observations; for example, for the open ocean or lakes a critical velocity in the neighborhood of 0.68 feet per second has been reported, and earlier laboratory studies have given values ranging from 0.7 to as high as 21.3 feet per second depending on water depth. In this program, determination of the critical wind velocity necessary for generation of waves on water was undertaken in small wind tunnel equipment fitted with a water-filled tank having the surface flush with the bottom of the wind tunnel.

10. Near Shore Wave Damping (K.P.H. Frey)

For offshore or amphibious operations, attenuation of waves by portable man-made dumping devices often is desirable or even essential. This problem has attracted attention for many years and a variety of temporary breakwater designs have been suggested. On the basis of earlier leads, this study has centered on the laboratory evaluation of a new cascade type breakwater installed within the zone of principal wave action near the surface. Tests of preliminary models in a tank twenty feet long, twelve inches wide and eighteen inches deep confirmed the interesting wave attenuation properties of the cascade breakwater.

11. Probabiiistic Approaches to Environmental Design Criteria in the Nearshore Zone (C.Y. Yang)

Construction projects of various types in the nearshore and backshore coastal regions must take into account the potential destructive effects of extreme storm waves. Conventionally, the engineering design approach involves extrapolation on the basis of past observations to indicate probable future storm hazards. Safety factors usually are included but are difficult to estimate in the coastal setting. Modern probabilistic approaches offer the rationale for predicting maximum tidal surges that may be encountered in coastal locations for which reliable highest tide data are available. In this study, three statistical methods of estimating the risk that previous maximum storm tides will be exceeded have been evaluated using tide data from Atlantic City, New Jersey and from Breakwater Harbor in Delaware Bay.

12. Calculation of the Shoaling and Breaking of Large Waves. (M.D. Greenberg)

Accurate prediction of the shoaling, breaking and run-up behavior of large waves entering shallow water is a valuable aid in the design of coastal and offshore installations. The present theoretical study of this problem is based on a continuous vortex sheet representation of both the free surface and its image. The SUMMAC code of Chan and coworkers at Stanford is free from the approximations that make present simplified calculation methods inaccurate when applied to large waves. In contrast with the SUMMAC method, the vortex representation automatically provides for exact satisfaction of the governing Laplace equation throughout the flow field as well as the tangent flow condition on the bottom boundary. Independent variables are thus reduced from <u>two</u> space variables plus time to one space variable plus time which should improve computational efficiency. The primary result of this research has been a further "reduction" of the problem; specifically, reduction of the dynamic free surface condition from a nonlinear integral equation to a first order ordinary differential equation.

13. Authigenic Phosphates in Coastal Plain Sediments (P.B. Leavens)

The stabilization of marine sediments to improve engineering strength properties is an important goal of ocean studies. Recently, marine clays collected at Sparrow's Point near Baltimore, Maryland, were reported to have improved strength characteristics owing to the presence of vivianite, an authigenic phosphate ($Fe_3(PO_4)_2.8H_2O$), which is known to occur in coastal plain sediments. This study is to explore the possibility that such improved properties might be developed in natural sediments by infusion of soluble phosphates.

14. Biogeochemistry of Marsh Sediments (F.M. Swain)

The vertical distribution of organic constitutents of marsh soils provides clues to the geological history of the area and to the inherent properties of accumulated sediments. As part of the general study of the Delaware coastal region, representative cores approximately 16 feet long have been collected in mildly saline marshes in the neighborhood of Lewes, Delaware. For the most part, core specimens were fast-frozen in the field and kept frozen until sampled for analysis.

15. Remote Sensing Program (J.D. Pennewell)

Remote sensing techniques, for example, high altitude aerial photography, offer attractive possibilities for characterizing many physical features of coastline areas such as those under investigation in this program. This fact in combination with the wealth of ground data being collected under this project has prompted scheduling of remote sensing overflights at various seasons as a total project activity. Planning and management of these missions has been delegated to a qualified consultant. Since many of the physical features of coastal regions provide excellent signatures in the visible and infra-red spectral ranges, recording with standard photographic equipment is possible.

(b) ONR Reports - A publication policy was adopted to number all papers, technical reports, conference proceedings and presentations in one ONR series for the period 1969 to 1972 as listed below.

	Technical Report Number
A Guide to the Geology of Delaware's Coastal Environments 1971. J.C. Kraft	T.R. No. 1
An Experimental Study of Wind Velocity Profiles Over a Wavy Surface. April, 1972. F.J. Merceret	T.R. No. 2
Sedimentary Facies Patterns and Geologic History of a Holocene Marine Transgression. June, 1972. Reprinted from Geological Society of America Bulletin, Vol. 82, p. 2131-2158, August, 1971. J.C. Kraft	T.R. No. 3
Biogeochemistry of Sediment Samples from Broadkill Marsh, Delaware. June, 1972. Reprinted from Journal of Sedimentary Petrology, Vol. 41, No. 2, p. 549-556, June, 1971.	T.R. No. 4
Marsh Gas in Northern Delaware and Its Effect on Stability of the Marsh Surface. June, 1972. F.M. Swain	T.R. No. 5
Statistical Prediction of Hurricane Storm Surge. June, 1972. Reprinted from Proceedings of the 12th Coastal Engineering Conference, September, 1970, Washington, DC C.Y. Yang, A.W. Parisi, and W.S. Gaither	T.R. No. 6
On Non-Stationary Random Wave Spectra. June, 1972. Reprinted from International Symposium on Stochastic Hydraulica, May 31-June 2, 1971, Pittsburgh M.A. Tayfun, C.Y. Yang and G. Hsiao	T.R. No. 7
Some Mathematical Concepts Related to Stochastic Spectrum Analysis. June, 1972. Reprinted from the ASCE National Structural Engineering Meeting, April 24-28, 1972, Cleveland, Ohio, G. Hsiao, C.Y. Yang and M.A. Tayfun	T.R. No. 8

A Reconnaissance of the Geology of the Sandy Coastal Areas of Eastern Greece and the Peloponnese. July 1972.
J. C. Kraft — T.R. No. 9

Evolution of Lewes Harbor. November 1972.
J. C. Kraft and R. L. Caulk — T.R. No. 10

On the DISA 55D15 Linearizer. June 1972.
F. J. Merceret — T.R. No. 11

Analog Model Study of Ground-Water Flow in the Rehobeth Bay Area, Delaware. July 1972.
S. R. Stegner — T.R. No. 12

Element Enrichment in Organic Films & Foam Associated with Aquatic Frontal Systems. November 1972. Reprinted from Journal of Geophysical Research, September 1972.
K. H. Szekielda, S. L. Kupferman, V. Klemas, and D. Polis — T.R. No. 13

Breakwater Studies in Wave Tanks. July 1972.
K. P. H. Frey — T.R. No. 14

Hydraulic Model Measurement of Tidal Currents Around Cape Henlopen, Lewes, Delaware. October 1972.
B. T. Lakshman and F. Camfield — T.R. No. 15

A Refraction Study and Program for Periodic Waves Approaching a Shoreline, and Extending Beyond the Breaking Point. October 1972.
B. S. L. Smith and F. Camfield — T.R. No. 16

Comparative Carbohydrate Geochemistry of Bay, Salt Marsh, and Deep Gulf Sediments. December 1971. Reprinted from Advances in Organic Geochemistry, 1971, p. 415-425.
F. M. Swain and J. M. Bratt — T.R. No. 17

Sediment Distribution in Southwestern Delaware Bay. October 1972.
R. N. Strom — T.R. No. 18

The Great Marsh, Lewes, Delaware: The Physiography, Classification, and Geologic History of a Coastal Marsh. December 1972.
G. K. Elliott — T.R. No. 19

Kelvin-Helmholtz Instability of Bounded Two-Phase Particulate Flows. December 1972.
J. Chou and B. Seidel — T.R. No. 20

Research in the Coastal and Oceanic Environment. Annual Status Report for 1971. September 1972. — T.R. No. 21

Research in the Coastal and Oceanic Environment. Annual Status Report for 1972. November 1972. — T.R. No. 22

Morphology and Vertical Sedimentary Sequence Models in Holocene Transgressive Barrier Systems. April 1973.
J. C. Kraft, R. B. Biggs, and S. D. Halsey — T.R. No. 23

Estimation of Stationary and Non-Stationary Ocean Wave Spectra. July 1973.
Mehmet A. Tayfun and Cheng Y. Yang — T.R. No. 24

Research in the Coastal and Oceanic Environment: Annual Status Report for 1973. November 1973. — T.R. No. 25

Sediment Transport in Random Waves. December 1973.
S. S. Liang and Hsiang Wang — T.R. No. 26

Suspended Sediment Observations for ERTS-1. November 1973. Reprint from Remote Sensing of the Environment, 1973.
V. Klemas, J. F. Borchardt and W. M. Treasure — T.R. No. 27

An Investigation of Electro-Optical Techniques for the Analysis of Suspended Sediments. December 1973.
Michael Salter — T.R. No. 28

Classification of Sandy, Coastal-Plain Coasts. May 1974.
Lance E. Kearns — T.R. No. 29

Biogeochemistry of Marsh Gases: Effects of Inorganic Constituents of Marsh Plants on Methane Evolution; and Carbohydrate Stability in Plants. November 1974.
F. M. Swain, J. M. Bratt, and J. Sherman — T.R. No. 30

Marsh Gas From the Atlantic Coastal Plain. March, 1975.
F.M. Swain
Reprint from: Advances in Organic Geochemistry, Proc., 6th International Congress of Organic Geochemistry, September 18-21, 1973, Reuil-Malmaison, France. T.R. No. 33

Middle-Late Holocene Evolution of the Morphology of a Drowned Estuary System: The Delaware Bay. April, 1975.
J.C. Kraft, R.E. Sheridan, R.D. Moose, R.N. Strom, C.B. Weil
Reprint from: Memoires de l'Institut de Geologie du Bassin d'Aquitaine. Proc. of International Symposium on Interrelationships of Estuarine and Continental Shelf Sedimentation, Bordeaux, France, July 9-14, 1973. T.R. No. 34

Mid-Holocene Paleogeography of a Lagoonal Complex Buried on the Atlantic Inner Shelf Off Delaware. April, 1975.
R.E. Sheridan, C.E. Dill, Jr., and J.C. Kraft
Reprint from: Memoires de l'Institut de Geologie du Bassin d'Aquitaine. Proc. of International Symposium on Interrelationships of Estuarine and Continental Shelf Sedimentation, Bordeaux, France, July 9-14, 1973. T.R. No. 35

III. Coastal Dynamics Program (1972-1975)

Beginning in 1972, the research program at Delaware has been reoriented toward developing predictive tools tailored to the Navy's needs in the sea coasts. Specifically, this new effort was concentrated in three major areas: (a) dynamic modeling of coastal conditions (b) stochastic prediction of coastal processes and (c) photo-optical determination of directional shallow-water wave spectra.

Research results were disseminated in terms of publications, reports, conference presentations and computer documentation. They are briefly summarized at the end of the report.

(1) Dynamic Modeling of Coastal Conditions (H. Wang, R.A. Dalrymple and V. Klemas)

The specific objective of the research is to develop a numerical computer model to predict short-term beach changes under the influence of environmental factors such as waves and currents. This research effort has been concluded in that a model has been developed with the inclusion of most major process elements that can be treated in a quantitative fashion.

During the course of these studies, in-depth investigations have also been made in a number of topics, both of fundamental and practical importance. In cooperation with other investigators, continued efforts have been devoted to field data collection off the Delaware coast. Such information as long term and short term wave climate, wave energy spectral transformation and related beach change were being collected and reported on. Theoretical and numerical studies on the mechanics of sediment movement, nearshore circulation and wave energy spectral transformation were also carried out to supplement the main objective as stated.

(2) Stochastic Predictions of Coastal Processes (C.Y. Yang, M.A. Tayfun, V. Klemas, G.C. Hsiao)

The general objective of the study was to develop probabilistic and statistical concepts and methods for the practical and reliable predictions of the physical, meteorological and geological parameters, and their effects on the seacoasts. The research efforts were concentrated on the prediction of the environmental conditions characterized primarily by the wind field, wind-generated waves and tides. The approach we took was essentially a stochastic one, which was the only scientific method suitable in dealing with realistic but random coastal processes.

Recognizing a need for prediction of extreme mean water level as an important input parameter to coastal process studies for planning and design of coastal installations and for marine operations, we applied Wemelsfelder's method (1961) based on a Poisson probability law, and Gumbel's theory of extremes (1958) to predict probabilities of high wave levels for Atlantic City, New Jersey, and for Breakwater Harbor, Delaware, using data recorded by the Coast and Geodetic Survey, Environmental Science Service Administration, U.S. Department of Commerce. Another important parameter in coastal design and planning is the wave energy, which is most concisely and completely defined by a wave spectrum. As a result of our intensive study on the particularly important problem of time-dependent or non-stationary spectra in a storm wave field, we developed an optimum design method for spectral estimation. In our study of storm waves, we realized that available wave data are limited particularly in the shallow coastal waters. Consequently, the problem of wave spectral variation with distance which links deep and shallow water waves was studied. One major result of this study is a method of analyzing sea surface profiles in a spatially inhomogeneous wave field. Parallel to the wave spectral studies, extreme significant wave height data based on ship observations in deep waters near Delaware Coast were studied along with long-term statistical predictions.

(3) Photo-Optical Determination of Directional Shallow-Water Wave Spectra (V. Klemas and M.A. Tayfun)

The objectives of this project were to develop a fast, safe and economical technique for real-time assessment of wave conditions before amphibious operations and to verify predictive wave models. To attain these objectives, optical Fourier analysis of aerial photographs and wave data from an airborne laser profiler were used to determine the directional spectrum of waves changing from homogeneous deepwater to nonhomogeneous shallow-water waves.

The Fourier transforms of wave patterns in aerial photographs were produced using the Barber-Stilwell technique, by illuminating the photographs with a laser beam and focusing the transmitted beam with a spherical lens. The transform pattern showed the dominant wave pattern as a circular spot of finite size at the appropriate wavelength and angle (Barber, 1949; Stilwell, 1969; Kasevich, 1971). The distance of the spot from the center of the pattern was inversely proportional to the wavelength. The finite size and irregular elongation of the spot were used to identify higher and lower frequency components in the wave spectrum. Microdensitometer scans across photographs of the optical Fourier transform can then be calibrated in terms of wavelength.

A test site on Delaware's Atlantic Coastline, two miles north of Indian River Inlet, was selected for reasons of convenient access and suitable bottom profile. Aircraft equipped with cameras and a laser profiler were flown along 100-mile long transects into shore, tracking waves going from deepwater to nearshore conditions. About 300 feet offshore in 20-foot depth, wave properties were measured daily, even in stormy weather, with long capacitive wave probes on towers, to test our approach over a wide range of wave, wind and skylight illumination conditions.

IV. PUBLICATIONS AND PRESENTATIONS

Since 1972 under the new ONR Geography Program, the policy of numbering publications of all types was discontinued. We list in the following publications and presentations in a combined format. Technical publications are separated into three groups by subject area in the following. These are: (1) dynamic modeling of waves, current, tides and shore changes, (2) stochastic modeling of waves, currents and tides and (3) photo-optical and other means of field determination of waves, currents, tides and shore changes.

Group 1: Dynamic Modeling of Waves, Currents, Tides and Shore Changes

Birkemeier, W.A. and R.A. Dalrymple, "Nearshore Water Circulation Induced by Wind and Waves," Proc. of the Symposium on Modeling Techniques, ASCE, San Francisco, 1975.

Dalrymple, R.A., Eubanks, R.A. and Birkemeier, W.A., "Wave-Induced Circulation in Shallow Basins," J. Waterways, Port, Coastal and Ocean Div., ASCE, in press.

Dalrymple, R.A., "Beach Cusps Formed by Intersecting Waves," Bull Geol. Soc. Amer., Vol. 87, No. 1, Jan., 1976.

Dalrymple, R.A., "Wave-Induced *Mass Transport in Water Waves*," J. Waterways, Harbors and Coastal Engrg. Div., ASCE, Vol. 102, May, 1976.

Dalrymple, R.A., "A Finite Amplitude Wave on a Linear Shear Current," J. Geophys. Research, Vol. 79, No. 30, Oct., 1974.

Dalrymple, R.A., "A Finite Amplitude Water Wave on a Bilinear Shear Current," Proc. 14th Coastal Engrg. Conf., Copenhagen, 1974.

Dalrymple, R.A., "A Mechanism for Rip Current Generation on an Open Coast," J. Geophys. Res., Vol. 80, No. 24, 1975.

Shiau, J.C. and Wang, H., "Wave Energy Transformation Over Irregular Bottom," J. Waterways, Port, Coastal and Ocean Div., ASCE, in press.

Wang, H. and Liang, S.S., "Mechanics of Suspended Sediment in Random Waves," Vol. 80, No. 25, J. Geophys. Res., 1975.

Wang, H., Dalrymple, R.A. and Shiau, J.C., "Computer Simulation of Beach Erosion and Profile Modification Due to Waves," Proc. of the Symposium on Modeling Technqiues, ASCE, San Francisco, Calif., 1975.

Wang, H. and Liang, S.S., "Sediment Transport in Random Waves," Tech. Rept. 26, College of Marine Studies, Univ. of Delaware, Oct., 1973, 105 pp.

Wang, H. and S.S. Liang, "Sediment Transport in Random Waves," Proc. of 14th International Conf. on Coastal Engrg., Copenhagen, June, 1974.

Wang, H., "Mechanics of Suspended Sediment in Random Waves," Presented at the AGU Topical Conf. on Transport Mechanism in the Nearshore Environment, Mystic, Connecticut, Sept., 1974. Also submitted to JGR for publication.

Wang, H. and Dalrymple, R.A., "Computer Simulation of Short-Term Coastal Processes and Associated Beach Transformation," Tech. Rept. to ONR Geography Branch, 1976.

Group 2: Stochastic Modeling of Waves, Currents and Tides

Baxter, L. and C.Y. Yang, "Fluctuation of Narrow-Band Sound Amplitudes for Long-Range Transmissions in the Deep Atlantic Ocean," J. Acoustical Society, Vol. 58, No. 3, with Lincoln Baxter, II, Sept., 1975.

Fallah, H., J. Sharma, and C.Y. Yang, "A Simulation Model for Design Tide Prediction," Proc. of the 15th International Coastal Engrg. Conf., ASCE, 1976.

Tayfun, M.A., C.Y. Yang, V. Klemas and H. Wang, "Analysis of Inhomogeneous Wave Number Spectra," J. Geophys. Res., Vol. 80, No. 24, Aug., 1975.

Tayfun, M.A., C.Y. Yang and G.C. Hsiao, "Optimal Design for Wave Spectrum Extimates," J. Geophys. Res., Vol. 80, No. 15, May, 1975. Also: presented at the 14th Inter. Conf. on Coastal Engrg., Copenhagen, Denmark, June, 1974.

Tayfun, M.A. and C.Y. Yang, "Transformation of Directional Spectrum in Shallow Water," invited seminar at Woods Hole Oceanographic Institution, March, 1975.

Tayfun, M.A., Dalrymple, R.A. and Yang, C.Y., "Interaction Between Random Waves and Shear Currents in Water of Varying Depth," Ocean Engineering, to appear in Vol. 6, No. 3, Jan., 1977.

Tayfun, M.A., "Linear Random Waves on Water of Nonuniform Depth," ONR Tech. Rept., May, 1976.

Yang, C.Y., M.A. Tayfun and G.C. Hsiao, "Extreme Wave Statistics for Delaware Coastal Waters," Proc. of International Symposium on Wave Measurement and Analysis, Braniff Place, New Orleans, La., Sept., 1974.

Yang, C.Y., M.A. Tayfun, "Extreme Wave Predictions," invited seminar at M.I.T. Civil Engineering Dept., Feb., 1974.

Yang, C.Y., and M.A. Tayfun, "Wave Predictions and Applications in Coastal Engineering," invited seminar at Woods Hole Oceanographic Institution, March, 1975.

Yang, C.Y., M.A. Tayfun and G.C. Hsiao, "Stochastic Prediction of Extreme Waves and Sediment Transport in Coastal Waters," Proc. of the Symposium on Stochastic Problems in Mechanics, Univ. of Waterloo, Canada, Sept., 1973.

Yang, C.Y., "Statistical Prediction of Extreme Wind, Waves and Tides for Ocean Engineering Operations," paper presented at the National Convention, ASCE, Denver, Colordao, Oct, 1975.

Yang, C.Y., Fallah, H. and M.A. Tayfun, "Review on Extreme Wind, Waves and Tides," Proc. Civil Engineering in the Oceans III, Vol. I, 1975.

Yang, C.Y. and M.A. Tayfun, "Random Water Waves and Some Other Problems in Stochastic Mechanics," Invited Seminar Applied Mathematics Inst., Univ. of Delaware, Feb., 1976.

Group 3: Photo-Optical and Field Determination of Waves, Currents, Tides and Shore Changes

Klemas, V. et al., "A Cost-Effective Sattelite-Aircraft-Drouge Approach for Studying Estuarine Circulation and Shelf Waste Dispersion," IEEE, Ocean 75, San Diego, Calif., 1975.

Klemas, V., R. Srna, W. Treasure, and R. Rogers, Satellite Studies of Suspended Matter and Aquatic Interfaces in Delaware Bay, Proceedings A.S.P. Symposium on Remote Sensing in Oceanography, Orlando, Florida, October 2-5, 1973.

Klemas, V., M. Otley, G. Davis, and R. Rogers, Mapping Coastal Water Properties and Current Circulation with Spacecraft, Second Joint Conference on Sensing of Environmental Pollutants, Washington, D. C., December 10-12, 1973. (EPA, NOAA, NASA, DOT, etc.)

Klemas, V., M. Otley, C. Wethe, R. Rogers, Application of ERTS-1 to the Management of Delaware's Coastal Resources, Proceedings NASA Third ERTS-1 Symposium, Washington, D. C., December 10-14, 1973.

Klemas V., M. Otley, W. Philpot, and R. Rogers, Correlation of Coastal Water Turbidity and Circulation with ERTS-1 and Skylab Imagery, Proceedings Ninth International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, April 15-19, 1974.

Klemas, V., F. Daiber, O. Crichton, and A. Fornes, Application of Automated Multispectral Analysis to Delaware Coastal Vegetation Mapping, Photogrammetric Engineering, Vol. XV, No. 4., April, 1974.

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Klemas, V., J. Borchardt, L. Hsu, G. Gredell, and H. Wang, Photo-Optical Determination of Shallow-Water Spectra, Proceedings International Symposium on Ocean Wave Measurement and Analysis, New Orleans, La., September 9-11, 1974.

Klemas, V., D. Bartlett, and R. Rogers, Skylab and ERTS-1 Investigations of Coastal Land Use and Water Properties, AIAA/AGU Conference on Scientific Experiments of Skylab, Huntsville, Alabama, Oct. 30 - Nov. 1, 1974.

Klemas, V., Bartlett, D., Philpot, W. and Rogers, R., Coastal and Estuarine Studies with ERTS-1 and Skylab, Remote Sensing of Environment, 3, 153-174, 1974.

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13. ABSTRACT

This report covers accomplishments for the period 1 September 1969 to 31 August 1975 of an interdisciplinary investigation under the program "Research in the Coastal and Oceanic Environment." The program had undergone a significant redirection as a result of the termination of the DOD Themis Program and the transfer of support to the Geography Programs of the Office of Naval Research.

Past activities at the University of Delaware represent a coordinated effort in research that covers a wide spectrum of topics including studies of energy exchange, sedimentary processes, vegetative growth, properties of marine soils and sediments, wave energy concentration, dissipation of waves in shore areas, wave breaking characteristics, wave defense devices, method of predicting wave height and direction, tides, winds and storm surges, dynamic geological models, remote sensing techniques for wave reconnaissance, mechanics of sediment movement and biogeochemistry of marsh gases. A substantial amount of basic information has been researched and documented.

With the vast amount of background information in hand, contributed both by Delaware researchers and other scientists in the nation, the research program at Delaware has been reoriented, beginning in 1972, toward developing predictive tools tailored to the Navy's needs. Specifically, this new effort was concentrated in three major areas--dynamic modeling of coastal conditions, stochastic prediction of coastal processes and photo-optical and field determination of wave spectra.

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